

exploring oceanography using satellite data

part 1 — sea surface temperature

The set of exercises that follow were designed to explore characteristics of ocean circulation using satellite data. These exercises introduce students to basic image processing skills for displaying and analyzing images. Each exercise has scientific discussions explaining what the student is observing. Students will use *SEE Image*, a version of NIH Image, to display and analyze the data sets.

The exercises are inquiry based and designed for advanced high school or introductory level undergraduate Earth science classes and associated Macintosh computer labs. They were designed to be used in concert with an electronic lecture that contains scientific background information on ocean circulation and satellite observations of the sea surface and includes graphics that can be made into viewgraphs or slides to facilitate development and delivery of lectures. This “eLecture” is the **Class Resources** component of this SEES module.

The password for the secured *Instructor's Guide* is available from the DAAC USO—you will need to provide proof that you are an instructor.

why study sea surface temperature

The seasons are an example of the annual variation of the Earth-Sun system. On the other hand, the dramatic warming of the eastern tropical Pacific Ocean during an El Niño event is an example of an interannual variation in the oceans. One reason scientists study the annual and interannual variability of the oceans and atmosphere is to identify and examine unusual or anomalous events that are caused by some natural or human induced forcing that may in turn cause severe weather patterns worldwide.

Sea surface temperature (SST) variability is an important parameter for monitoring climate change and periodic phenomena like El Niño. A global increase of SST, for instance, may be an indicator of global warming, and the change in its geographical distribution (which is what happens during an El Niño) can be a sensitive indicator of climate change.

In these exercises you will use research-quality SST data to investigate

- Geographical distribution of SST planetwide and associated features of ocean circulation
- Seasons, or the seasonal cycle (also called the annual variation) as expressed in SST
- Year-to-year variability, also known as the interannual variation, of SST
- How SST during an El Niño event varies from SST during “normal” conditions.

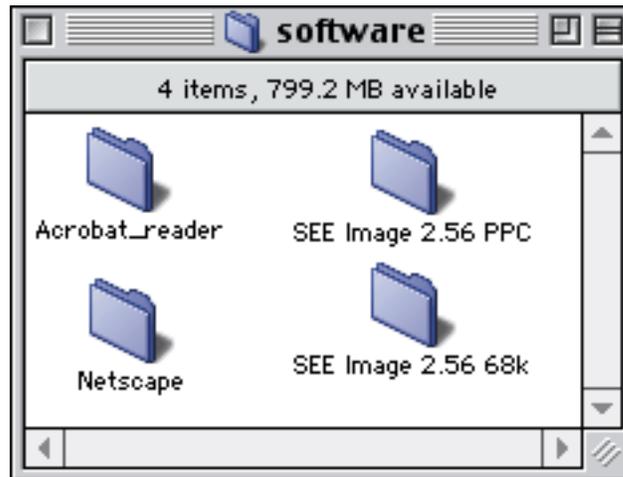
global monthly sst data set for 1982–1998

The data set you will use for these exercises is composed of gridded, monthly averaged SST measurements from both spaceborne instruments and ocean buoys and ships. The satellite SST measurements are derived from the Advanced Very High Resolution Radiometer (AVHRR) aboard the NOAA polar orbiting satellites. During the period 1982–1989, the *in situ* data, which consist of logbook and radio reports, were obtained from the Comprehensive Ocean Atmosphere Data Set. For the more recent periods, 1990–present, the *in situ* data were obtained from radio messages carried on the Global Telecommunications System. These data are produced as a real-time global SST analysis by Dr. Richard Reynolds of the Climate Modeling Branch of the National Centers for Environmental Prediction of the National Oceanic and Atmospheric Administration (NOAA). The data consist of 202 monthly files covering the period 1982–1998 and containing monthly averages of SST.

getting started

Before you begin to work on these exercises you'll need to install *SEE Image*, have the data you'll need for these exercises loaded and organized, and make sure your computer and software are set up correctly.

SEES CD users, double click the CD's icon, then double click the Software folder.



Choose the SEE Image version that matches your computer type and drag that folder onto your hard drive.

SEES Web site users, go to

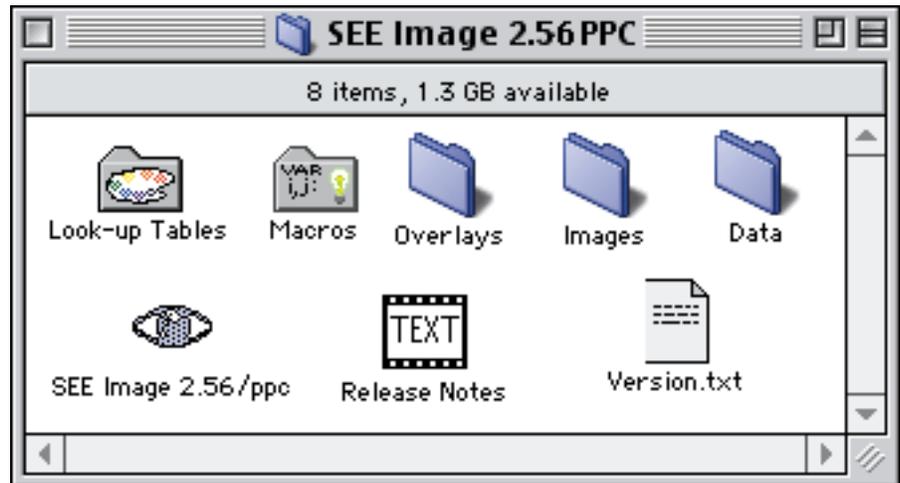
<http://see.gsfc.nasa.gov/edu/SEES/>

Under **Oceanography**, click **Computer Lab Resources** then click **Software**. Downloading instructions are given on the site. Follow them, then sit back and relax while the file downloads. Once the download is complete, the following icons will appear on your desktop.



NOTE: The software is updated occasionally. The number after "SEE Image" indicates the version. Check the Web site periodically for the latest version.

You now have a folder labeled **SEE Image** on your desktop that contains the program (whose icon is an eye), some Release Notes, a “version.txt” file, and five folders. Drag that folder onto your hard drive.



SEE Image is a modified version of NIH Image (<http://rsb.info.nih.gov/nih-image/Default.html>). To use the various functions necessary for the exercises, *SEE Image* must be configured properly. Instructions for configuration are given at the start of each exercise. If you are unfamiliar with *SEE Image*, please work through these exercises in order, from one through four. If you and your students are familiar with NIH Image or *SEE Image* and do not need a complete tutorial, each exercise may be used as a “stand-alone” unit.

loading the data

Navigational paths for moving through the hierarchical directory structure of your computer and SEE Image materials appear as follows:

Desktop | your hard drive (HD) | the main SEE Image folder | next item of choice | etc.

SEES CD users, go to

Desktop | SEES CD | data

then click and drag the data folder for the chosen exercise into

Desktop | HD | SEE Image | Data | Oceans

It's very important that you put the data in this directory because all instructions use this path.

SEES Web site users, go to

<http://see.gsfc.nasa.gov/edu/SEES/>

Under **Oceanography**, click **Computer Resources**. Then click **Data** and click on the data sets you want. When the download is complete and the archive is unpacked, which will occur automatically, you'll see three new icons on your desktop for each set of data you downloaded. Two are document icons that will have one of these file name extensions: **.sea.hqx** or **.sea**. You may trash those files. The third is a folder icon. Drag that folder into the "Oceans" folder as described above.

setting up your computer

Pull down the  menu, choose **Control Panels** then choose **Monitors & Sound (Monitors)** and set the colors to "thousands" or "millions."

If your hardware doesn't offer this option, you can still run SEE Image using 255 colors, but your desktop colors may change. It's not permanent. Your desktop colors will reset to your original choices when you quit SEE Image.

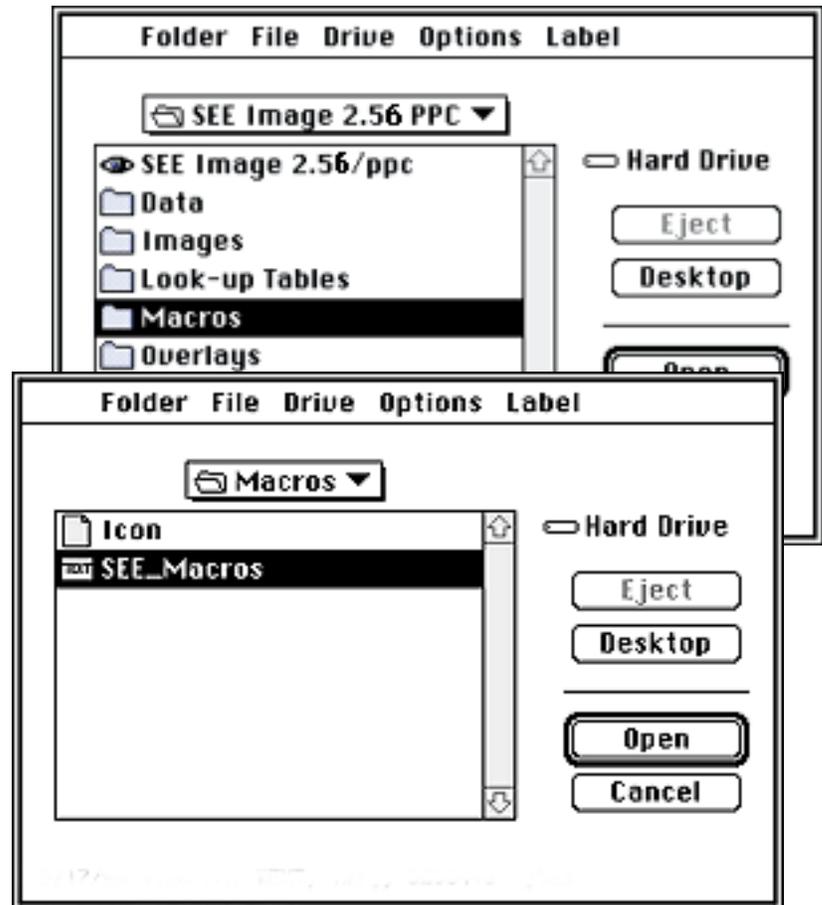
SEE Image will install with just enough memory allocated (~11 MB) to run the exercises. If you want to import more images than those used in these exercises, you'll need to increase this amount or you'll get error messages while loading or creating images. To increase the memory, click once on the SEE Image icon to highlight it, pull down the **FILE** menu and choose **Get Info**. Increase the number in the Preferred Size box at the bottom right.

NOTE: Even if you don't get error messages, it's a good idea to increase the memory allocation if you have enough available. All software works better and often faster with more room to move.

loading the see image macros

Special programs called macros were designed specifically for working with sea surface temperature data. Macros either perform specific tasks unavailable in the original software or automate a series of steps that are tedious if performed manually.

Pull down **SPECIAL** and choose **Load Macros**. Highlight and **Open** as shown.



NOTE: You'll have to load the macros every time you start *SEE Image*.

Comprehensive *SEE Image* tutorials were developed for Total Ozone Concentration and Global Land Vegetation data and are available from the Studying Earth's Environment From Space Web site: <http://see.gsfc.nasa.gov/edu/SEES/>. These tutorials may also serve as reference manuals for processing images for incorporation into another document or for exporting data into another application. They provide more detailed instructions for some operations than are found in these exercises.

list of exercises

Exercise 1—Investigating the Characteristics of the Global Monthly Sea Surface Temperature (SST) Data Set for 1982–1998

- File type and file name description
- Opening and displaying a global SST data image
- Adding color to the image
- Understanding image windows and images
- Studying data spatial resolution
- The relationship between pixel value and SST in degrees Celsius
- Using *SEE Image* to calibrate pixel values to SST in degrees Celsius

Exercise 2— Observing Geographic, or Spatial, Variation of SST

- What determines where the ocean is warm and cold?
- Qualitatively observing the geographic distribution of SST
- Quantitatively observing the geographic distribution of SST

Exercise 3—Observing the Seasonal Variation of SST

- Preparing the data
- Using the density slice tool to observe monthly changes in SST
- Investigating seasonal variations in SST from an animation
- Investigating SST seasonal variations from a montage
- Creating a time-series of SST to observe seasonal variations
- Using *SEE Image* math to observe the seasonal variation in SST
- Advanced exploration

Exercise 4—Observing the Year-to-Year, or Interannual, Variation of SST